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ABSTRACT

The use and effectiveness of gaming techniques in educational computer software was investigated through an analysis of 170 in-depth evaluations of commercially-available educational computer programs. These evaluations, conducted by the Educational Products Information Exchange (EPIE) Institute, dealt with design attributes relevant to all programs as well as attributes relevant only to the gaming aspects of a program. General coding categories were copyright date, subject area, intended users, instructional approach, EPIE rating, and gaming. Gaming-related attributes coded were motivation, effectiveness, interactivity, confusion, and arcade (whether the gaming aspect of the program employs techniques used in video arcade games). Results indicate that gaming is now a major and increasingly-prevalent technique being used in the design of educational computer programs. The motivational appeal of gaming programs was consistently high, while their effectiveness varied depending on the context in which they were used. It is suggested that the instructional impact of educational computer games may be maximized by carefully matching specific gaming techniques to such factors as the content, instructional approach, and users of a program. Nine references are listed. (LMM)

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Gaming Approaches in Educational Software: An Analysis of Their Use and Effectiveness

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Abstract

The use and effectiveness of gaming techniques in educational computer software was investigated. An analysis of 170 in-depth evaluations of commercially available educational computer programs, carried out by the Educational Products Information Exchange (EPIE) Institute, dealt with design attributes relevant to all programs and attributes relevant only to the gaming aspects of a program. Results indicate that gaming is now a major, and increasingly prevalant, technique being used in the design of educational computer programs. The motivational appeal of gaming programs was found to be consistently high, while the effectiveness of these programs varied depending on the context in which they were used. The findings demonstrate that in order to maximize the instructional impact of educational computer games, specific gaming techniques need to be carefully matched to factors such as the content, instructional approach, and users of a program.

Gaming Approaches in Educational Software

While there is general agreement that computer based instruction can be as effective or more effective than traditional classroom approaches, there is less of a consensus on exactly what attributes contribute most to the effectiveness of an educational computer program (Forman, 1980; Kearsley, Hunter, and Sidel, 1983). A plausible and widespread assumption is that the use of the computer leads to increased motivation, attention span, and engagement in the instructional task.

John Carroll (1963) suggested that learning is dependent on the extent to which students actually spend their time in learning what they need to learn. Time, in this case, refers to the amount of time students are actively engaged in learning rather than the amount of time students are exposed to learning activities and materials. Carroll's model is most often referred to as time-on-task. More recently, Benjamin Bloom (1980) has indicated that in addition to having a possible causal relationship with school learning, time-on-task can be altered by the instructional process, and this alteration would have direct consequences for the learning that will take place.

The motivational pull of the computer and its ability to engage students in specific instructional activities (eg. increasing time-on-task), seem to be major claims for its effectiveness. By altering some of the attributes of an educational computer program that contribute to its appeal, we might positively affect learning. This makes it essential that we begin to assess those attributes of educational computer programs that are most closely associated with motivating students and how these attributes relate to the instructional task.

Explanations for the high motivation and on-task behavior associated with computer based education center on the novelty of the computer and its interactive nature. As this novelty begins to fade through continued exposure to home and school computers and experience with sophisticated arcade and home game machines, educational software producers are increasingly turning to various gaming approaches in order to insure and increase student motivation and interest. There is still disagreement as to whether embedding instruction in the context of an educational game will enhance attention and produce superior learning, or prove distracting and impair initial learning (Lepper 1981). In order to address this important issue in educational computing, this paper presents initial research on the use and effectiveness of educational computer games. Specifically the paper will report on the extent to which educational software employs gaming

approaches; describe ways in which these approaches are being used; and begin to assess the overall effectiveness of gaming approaches found in educational software.

Method

Sample

Since over five thousand educational programs for microcomputers have been identified (TESS, 1984), the task of selecting and evaluating a representative sample of educational software was beyond the scope of this study. A purposive sample of 170 in-depth evaluations of commercially available educational computer programs carried out by the Educational Products Information Exchange (EPIE) Institute (EPIE Institute, 1984) was used. The programs in the sample covered a wide range of subject areas, audiences, and instructional approaches. They were selected for evaluation by EPIE because they were identified as highly visible products that were either aggressively marketed or in wide-spread use.

The instrument used to carry out the evaluations (EPIE Institute, 1983) is sixteen pages long covering 83 points of information. It solicits an exhaustive amount of information dealing with both the instructional design and the software design of a program.

Each program was evaluated by at least two analysts working independently. Analysts are in most cases teachers who have been trained and certified in using the evaluation instrument, and the courseware they evaluate is matched to their subject area and the age/grade range they teach. Most programs are also tried out with students in order to elicit user feedback. After completing their evaluations separately, the analyst's meet with a third evaluator or "synthesizer" in a debriefing to either resolve or articulate differences. The synthesized evaluation is then edited into a final two or four page review depending on the size and scope of the program.

Procedure

The evaluations used in this study were designed to provide a wide range of information on all aspects of educational computer programs. This information is intended to help educational consumers make purchase decisions. In order to elicit as much information relevant to the use of gaming techniques in an organized, manageable, and consistent way; the author developed a coding scheme that looks at categories relevant to all programs and attributes relevant only to the gaming aspects of a program. A data base was created for this coded information to allow for efficient sorting and analysis.

The categories coded for all programs were:

1. Copyright Date: The year in which the program was published.
2. Subject Area: The main instructional content of the program. Subject areas that made up less that ten percent of

the total sample were not included in the study. The subject areas that were included are: Early Childhood Education, Logic/Problem Solving, Mathematics, Language Arts, and Reading.

3. Intended Users: Educational computer programs often specify a wide range of users in order to attract the largest possible audience. In order to organize intended users in a manageable way, the were grouped by the youngest specified user. The groupings used in the study are: Young Children (below first grade) through Adult, Early Elementary (starting at grade one) through Adult, Elementary (starting at grade four) through adult, Junior High (starting at grade seven) through Adult, Senior High (starting at grade ten) through adult, and All Users. For example, a program specifying users as grades four through six and a program specifying users as grade five through adult would both be grouped under Elementary. In almost all cases the content of the program was closely correlated with the lower end of the age/grade range it was placed in.

4. Instructional Approach: This category refers to the primary approach the program uses to present its content. The programs in the sample were identified as: Drill and Practice - programs where instruction in a concept, skill, or process presented and developed in the classroom can be practiced and refined at the computer; Tutorial/Drill and Practice - programs that are intended to stand alone as an instructional entity in presenting skills and concepts, usually including drill and practice exercises; Logic/Problem solving - programs that offer students the opportunity to solve novel problems, usually through combining previously learned rules into a new higher-order rule; Simulation - programs that attempt to represent some key aspects of an environment within which the student will have to make decisions and will be informed of the results of those decisions without experiencing the real consequences of possible misjudgements; Tool - programs with no instructional content, that usually either transfer to the computer or make easier routine clerical tasks.

5. Rating: In addition to providing detailed descriptive and evaluative information, the EPIE reviews also include ratings of each program. Ratings on a scale of one to ten for both the instructional design of a program, which covers the programs goals and objectives, educational content, methodology/approach, documentation, and evaluation/testing; and the software design of the program, which includes aspects of its technical quality, use of graphics and audio, user control/interactivity, branching, and management system/record keeping were coded.

6. Gaming: Since one of the main objectives of this study was to assess the extent and ways in which gaming approaches were being used in educational computer programs, the definition used in coding this category was quite broad.

Programs coded as employing a gaming approach generally fit into a model described by Lepper (1981) where rather than simply presenting relevant problems in abstract form, problems are presented in a more intrinsically motivating fashion. In most cases this included one or more of the elements of challenge, control, fantasy, and curiosity identified by Lepper and by Malone (1981) as making computer games fun and intrinsically motivating. Based on those attributes, gaming in this study ranges from text based social studies simulations, to arcade style arithmetic drills, and puzzle like logic activities.

The attributes relevant to gaming techniques that were coded are:

1. Motivation: A direct statement or implication in the evaluation that the gaming aspect of the program is likely to lead to greater student interest in and motivation for using the program.

2. Effectiveness: A direct statement or implication in the evaluation that the gaming aspect of the program is an effective method of involving student in the instructional task.

3. Interactivity: There are many definitions of interactivity. Based on the information available in the evaluations used in the study, it is a measure of whether the gaming aspect of a program is more than just a reward or reinforcement for completing an instructional task. The gaming aspect of a program was coded as interactive only if it was integrated into into a program in a way that made it an essential part of the instructional task.

4. Confusion: A direct statement or implication in the evaluation that the gaming aspect of the program would be difficult to learn and/or understand, causing possible confusion and frustration for the user.

5. Arcade: Based on the information provided in the evaluations, this is a measure of whether the gaming aspect of a program employs techniques used in video arcade games. In most cases this includes an emphasis on graphics and themes of chase, aggression, and/or conquest.

Results and Discussion

Extent to Which Gaming Approaches Were Used

Gaming is a major technique used in educational software. Almost half (48%) of all the programs in the sample used some sort of gaming technique (Table 1). The use of these techniques is also expanding. Only 40% of the programs with 1981 copyright dates used gaming techniques, while 52% of the programs with 1982 copyright dates and 57% of the programs with 1983 copyright dates used some sort of gaming technique (Table 2).

Ways in Which Gaming is Being Used

Subject areas. Two major applications were games that are used to support traditional content areas (eg. spelling,

arithmetic, social studies, etc.), and games where the educational content is in the game itself. In most cases games in the second group revolve around logical thinking and problem solving skills. Although only 9% of all the programs in the sample were solely devoted to logic/problem solving, almost all of these programs (93%) used gaming techniques. Mathematics programs made up the largest number of programs in the sample (30%) with only 37% of those programs using gaming techniques. Approximately half (46%) of the Language Arts programs in the sample (22% of the total) used gaming techniques. Fifty percent of the Reading programs in the sample used gaming techniques. The only other area represented by a significant number of programs (10% of the total) was Early Childhood Education. Fifty-nine percent of these programs, usually dealing with skills such as reading readiness or number/letter recognition, employed gaming techniques (Table 3).

Instructional approach. Drill and practice was the dominant instructional approach used by most of the programs in the sample, represented by 59% of the total. Of these programs, about half (51%) used gaming techniques. Tutorial programs, that in most cases included drill and practice exercises, made up 21% of the sample with only 6% of these programs using any kind of gaming approach. As would be expected, almost all of the programs using a logic/problem solving approach (13% of the sample) or simulation techniques (4% of the sample) used gaming approaches (Table 4).

Intended users. Over 80% of the programs in the sample were predominately targeted to students with an age/grade range of pre-kindergarten through the elementary grades. Gaming approaches were more likely to be used with younger children. Of the programs primarily targeted to children below the first grade (18% of the sample), 65% used gaming techniques. Half of the programs with target audiences starting at first grade (33% of the sample) employed gaming techniques, while programs with target audiences starting at the fourth grade (31% of the sample) used gaming techniques only 41% of the time (Table 5).

Interactivity. Gaming techniques that are designed in a way that make them an essential part of the instructional task, that are not just rewards or reinforcement for successfully completing a task, are rapidly becoming the dominant gaming approach used in educational software. Of all the games in the sample, 65% used these interactive techniques (Table 1). The percentage of gaming programs that went beyond reward and reinforcement rose from 53% of the programs with 1981 copyright dates to 76% of the programs with 1983 copyright dates (Table 2). Reading and Language Arts are the subject areas that rely most strongly on gaming for reward, with just over half of the gaming techniques identified in these subject areas used as rewards or reinforcement (Table

3). As we would expect almost all of the Logic/Problem Solving and Simulation programs use the more interactive techniques, while only half of the drill and practice and tutorial/drill and practice gaming programs made the game a significant part of the instructional task (Table 4). Interactive approaches were more evenly spread out across the age/grade ranges. Over 60% of the gaming programs in all of the grade ranges significantly represented in the total sample used interactive gaming techniques (Table 5).

Arcade techniques. The use of arcade style graphics and gaming techniques are also beginning to play a significant role in educational software. Although only 30% of all the gaming programs in the sample used arcade techniques (Table 1), they grew from 18% of the gaming programs with 1981 copyright dates to 41% of the gaming programs with 1983 copyright dates (Table 2). Gaming programs in Mathematics were most likely to use arcade techniques (47%), followed by gaming programs in Language Arts (35%) and Reading (27%) (Table 3). Forty-two percent of the drill and practice gaming programs used arcade techniques, with logic/problem solving games being the only other instructional approach using these techniques (14%) (Table 4). Arcade techniques were used in 15% of the gaming programs primarily targeted to users below the first grade, 46% of the gaming programs targeted to users above the first grade, and 32% of the gaming programs targeted to users above the fourth grade (Table 5).

Effectiveness of Gaming Approaches

Motivation. Incorporating gaming techniques into educational software programs was judged to lead to increased student interest and motivation in 91% of the programs that used these techniques (Table 1). The level of motivational appeal of gaming programs was consistently high for all copyright dates, subject areas, instructional approaches, and intended users (Tables 2, 3, 4, and 5).

Effectiveness. There is much less consistency in the effectiveness of these approaches. While gaming techniques were judged to be effective in 59% of all of the programs in the sample that used them (Table 1), gaming programs that were judged to be effective declined from 71% of those with 1981 copyright dates to only 41% of those with 1983 copyright dates (Table 2). Some problems with gaming approaches were detected through the effectiveness ratings of gaming approaches in different subject areas. About 80% of the programs in each of the subject areas of Early Childhood Education, Logic/Problem Solving, and Mathematics that used gaming approaches were judged to use them effectively. Only 29% of the Language Arts and 36% of the Reading programs that use gaming approaches were judged to use them effectively (Table 3). A closer examination of the individual program evaluations indicates that gaming approaches that worked well in some subject areas (eg. arcade games in arithmetic) were often spun off out of

context into Language Arts or Reading programs where they make little sense. Drill and practice games were judged to be the least effective (52%) of the instructional approaches using gaming techniques (Table 4). Effectiveness of gaming techniques also decreased with the age of the target audience. While 70% of the gaming programs targeted to pre-schoolers were judged to be effective; 61% of the gaming programs designed for first grade and older, and only 50% of the gaming programs targeted at students in the fourth grade and beyond were judged to use these techniques effectively (Table 5). Interactivity seems to be correlated with effectiveness. In all categories except copyright date, there is a close correlation between gaming approaches that were judged to go beyond reward and reinforcement, and gaming approaches that were judged to be effective (Tables 1, 2, 3, 4, and 5). Analysis of individual evaluations indicates that a major reason for the lack of effectiveness of some gaming programs, especially drill and practice programs and programs for users beyond the early grades, is that the instructional task is overshadowed by the gaming technique. In these cases the games become the center of attention and detracts from the educational content of the program.

Confusion. A growing problem related to the effectiveness of the gaming techniques used in educational software is the extent to which they are at least initially confusing and/or difficult to master. Almost one third (31%) of the gaming programs in the sample were judged to be confusing (Table 1). This percentage rose from just 14% of the gaming programs with 1981 copyright dates to 41% of the programs with a 1983 copyright (Table 2). An examination of the evaluations of gaming programs judged to be confusing indicates two possible causes. The first is that gaming techniques, especially arcade style games, used in many drill and practice programs are never fully explained. This can lead to situations where students invent their own rules for a game that in most cases will work against the instructional intent of the program. The other major cause of confusion in gaming programs centers on the difficulty level and purpose of many of the logic/problem solving activities. In many cases these programs were judged to be too difficult for their intended audience and would require extensive teacher/adult intervention before students could proceed alone. The evaluations also pointed out that since most of these programs deal with content not normally found in the traditional curriculum, they need to, but usually don't, provide enough information for teachers on what the educational objectives of the activities are, and how they could be integrated into the curriculum.

Rating. The overall EPIE ratings of both the instructional design and software design of programs employing gaming techniques are generally, but not overwhelmingly,

positive. Fifty-seven percent of the programs that received an above average rating (average being 5 on a 10 point scale) for both the their instructional design and software design used gaming techniques. Programs in which both ratings were average or mixed (mixed meaning an above average instructional or software design rating and an average or below average software or instructional or software design rating) also used gaming techniques 57% of the time. Programs that received below average ratings for both instructional and software design used gaming techniques only 29% of the time (Table 6).

Conclusions

Gaming is now a major approach being used in the design and development of educational computer software. The number of programs using gaming techniques is growing at a steady rate. These techniques are being use with a variety of instructional approaches, in most subject areas, and across all age/grade ranges. The motivational appeal of gaming approaches is consistently high, regardless of the specific technique. The effectiveness of gaming techniques, however, seems to vary depending on the context in which it is being used.

It seems clear that educational computer games can be powerful instructional tools, but specific gaming techniques need to be carefully matched to a programs educational intent. Future research into creating effective educational computer games should address the context (eg. the subject area, instructional approach, users, etc.) in which specific gaming techniques work best. Software developers need to make sure that all of the elements of a program's design (including gaming techniques), work together to maximize its educational impact and positively effect learning.

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Table 1
Gaming Attributes Related to All Programs Using Gaming Techniques

Gaming Attributes	All gaming programs
Motivating	91%
Effective	59%
Interactive	65%
Confusing	31%
Arcade	30%

Note: n of all programs in the sample = 170
n of gaming programs in the sample = 81 (48%)